PROGRESS UPDATE ON DECISION AIDS FOR EO WEAPON SENSORS

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The Geophysics Directorate of the USAF Phillips Laboratory manages a Weather Impact Decision Aids (WIDA) program that develops software to predict the influence of the weather and other environmental parameters on the operational performance of Electro-Optical (EO) sensors (infrared, laser, visible) used in air-to-ground munitions, navigation systems, and Night Vision Goggles (NVGs).

The WIDA program has established unique measurement facilities to evaluate EO target and background signature models in the infrared (3-5 and 8-12 micron) and near-infrared (.7-.9 micron). EO data and imagery along with supporting meteorological and geophysical data are collected for systematic model validation. Experiments have been conducted at a fixed site at Hanscom AFB for nearly two years. A mobile van is also being equipped to conduct infrared and NVG experiments at several sites on Otis ANGB, Cape Cod, MA. Infrared experiments began in Jun 96 with NVG experiments to follow in 1997.

WIDA experiment data are being used to evaluate and develop the physics models used to predict the environmental impacts on EO sensors. These models drive WIDA applications software that determines target acquisition data for mission planning/execution activities and produce realistic target-area scenes for use by aircrews on automated mission planning systems during mission rehearsals.

An overview of the WIDA program was presented at the Dec 95 BAC. This presentation will report on progress made over the past year and provide an update on anticipated WIDA end-products and completion dates.

1. Introduction

The Weather Impact Decision Aid (WIDA) program is developing new products that provide performance predictions for EO Systems. Current focus is on IR and night vision systems. WIDA efforts translate conventional weather data into information needed by the warfighter to exploit the battlespace environment. WIDA products provide warfighters with predictions and visualizations of the influence of weather and other environmental parameters on Electro-Optical (EO) Sensors (infrared, laser, visible) used in air-to-ground munitions, navigation systems, and night vision goggles (NVGs). These products allow mission planners to factor weather into key decisions such as mission time, target approach heading, tactics, and weapons selection. They provide combat ah-crews with detection/lock-on range predictions and/or target scene predictions, facilitating target location and positive identification.

The current WIDA program is divided into three components:

a. Air Combat Targeting/Electro-Optical Simulation (ACT/EOS) - Develops and upgrades models for predicting and visualizing weather impacts on air-to-ground IR targeting and navigation.

b. Night Vision Goggle (NVG) Operations Weather Software (NOWS) - Develops and integrates models for determining the influence of weather and illumination on the performance of NVGS.

c. Weather Automated Mission Planning Software (WANE%) - Integrates new IR and NVG weather impact models developed in ACT/EOS and NOWS with existing laser and TV weather impact models into a product that will automate the generation of EO weather impacts in force-level automated mission planning systems.

The above components are discussed in more detail in the following sections, The validation effort is also described.

2. Air Combat Targeting/Electro-Optical Simulation (ACT/EOS)

The ACT/EOS effort was organized when the final version of the EO Tactical Decision Aid (EOTDA) was being completed. EOTDA Version 3.1 was delivered in 1994, and is currently being used operationally by the AF and Navy. This product was developed during a period of relatively primitive PC and workstation capabilities, limiting its utility. Furthermore, the EOTDA had only limited validation, is tedious to run, and often requires subjective manipulation by forecasters to adjust for discrepancies or bias in the core physics models.

The ACT/EOS objectives are to model weather effects on air-to-ground IR targeting systems and develop tools to enhance mission planning and execution. The models fall into the following three categories:

a. Thermal Contrast - Physics models are used to calculate IR radiances of elements of the targets and surrounding terrain. The current EOTDA uses TCM2. ACT/EOS is upgrading TCM2 for targets, and evaluating radiance models developed by the Smart Weapons Operability Enhancement Program (SWOE) for backgrounds. The upgrade to TCM2 is being based on TCM2 assessment measurements made using a FLIR 2000 IR sensor to observe simple test targets along with a comprehensive suite of meteorological observation equipment including a TPQ-11 cloud profiling radar. Data are being used to identify weather sensitivities causing differences between observed and predicted radiances. Current modeling is for 8-12 μm; a 3-5 μm model will be added in the future.

b. Atmospheric Transmission - Atmospheric transmission is calculated using MODTRAN, but calculation time is minimized using a spatial interpolation scheme developed for ACT/EOS.

c. Sensor Performance - Sensor performance modeling characterizes the ability of specific IR sensors to distinguish targets and backgrounds. ACT/EOS is developing an improved sensor performance model to overcome limitations in the models currently used in the EOTDA.

In addition, ACT/EOS is developing automated data management techniques to drive the above models. Geographic data sets are generated using ARC/INFO, a commercial Geographic Information System (GIS). Geographic data sets are generated from a variety of sources, including National Imagery and Mapping Agency (NIMA, formerly DMA), USGS, commercial satellites, and national imagery, and can support large areas (e.g. 40 km x 40 km at 10m resolution). The GIS is being programmed to fully automate this process. ACT/EOS models are also driven using real-time weather derived from the AF Automated Weather Distribution System (AWDS).

The models described above support the development of the following two software packages.

a. IR Target-scene Simulation Software (IRTSS) - This product provides an IR visualization of the target scene (currently 8-12 μm, but 3-5 μm will be added). The visualization capability includes terrain shadowing, realistic vegetation graphics and animated fly-throughs that allow for 3-dimensional positioning of the sensor to view the scene from any angle. IRTSS is primarily being developed for incorporation into the AF Mission Support System (AFMSS) that will support aircrew mission planning and execution. It is being evaluated by the 46th Test Wing and 46th Weather Squadron at Eglin AFB, FL. Pilots are briefed using IRTSS, and cockpit video and meteorological validation data are returned for analysis and product upgrade.

b. Target Acquisition Weather Software (TAWS) - TAWS is currently planned as a replacement for the EOTDA. ACT/EOS will provide the IR portion of TAWS. Requirements for TAWS are being discussed with AF Weather and the Naval Research Lab, Monterey. As a minimum, TAWS would provide more accurate acquisition and lock-on ranges, improved guidance on tactics, far superior visualizations, probability outputs, ability to support multiple taskings, and guidance on weather sensitivities.

3. Night Vision Goggle (NVG) Operations Weather Software (NOWS) - The NOWS effort began with a deficiency in AFSOC weather support to covert night-time helicopter air refueling using NVGS. After meeting with pilots of the 9th Special Operations Squadron and AFSOC weather personnel in March 91, Phillips Lab (PL) Geophysics Directorate initiated an R&D effort to predict weather impacts on the performance of NVGs. A contractual effort began in FY92. The prototype NOWS was delivered in FY94 and demonstrated to AF Weather. This led to a greatly expanded list of requirements for NOWS from AFSOC and ACC to support differing scenarios, targets, backgrounds and hazards for NVG operations. NOWS Version 1.0 was delivered in FY95 for evaluation by AFSOC weather (1 6th 0SS). The NOWS Graphical User Interface (GUI) and products were developed in close coordination with AFSOC.

NOWS Version 3.0 was delivered in Dec 96 to ACC and AFSOC for evaluation at more than 30 operational weather units including those in PACAF and USAFE. The current version offers distinct advantages over other NVG support products including:

a. Physics-based models incorporating relevant weather for target/background detection range,
b. Upward and downward lines-of-sight,
c. Atmospheric attenuation and path radiance effects, and
d. NVG sensor modeling

NOWS provides worldwide map backgrounds for displaying, choosing, and tracking missions. It provides alerts to NVG operations hazards such as loss of horizon and towers, and provides NVG ranges as a function of user-selected probabilities. It also depicts optimum azimuth to approach a target or background. Weather-data input is automated with manual override capability.

The recently delivered NOWS 3.0 provides terrain elevation and features, full sensor bandpass spectral computations, an urban illumination model, and map-based color-coded output products. Future plans call for modeling individual light sources, terrain shadowing and masking effects, and incorporation of additional customer requirements.

4. Weather Automated Mission Planning Software (WAMPS) - Currently, weather impacts on systems and operations are not included in force-level automated mission planning systems. In order to support the appropriate selection of weapon and navigation sensors for hundreds, or even thousands of sorties, it is imperative that mission planners have WIDAS that automatically assess weather impacts for specific sensors against selected targets and backgrounds.

A survey of EO requirements was conducted for the WIDA program. This study acknowledged the importance of understanding and exploiting weather effects on EO systems. The survey of planners and pilots pointed out numerous WIDA requirements including the need for simultaneous guidance for multiple targets, guidance for weapon selection, target-area visualization, and more wavelengths than the current EOTDA.

Whereas TAWS is primarily a tool to support mission execution, WAMPS is envisioned as a force-level (24-72 hrs) stoplight weather impact mission planning capability. By providing red/yellow/green (unfavorable/marginal/favorable) guidance for each weapon/target combination, planners can better select weapons or alternatives or modify times-over-target. WAMPS will integrate new technologies developed in the PL WIDA program with other decision aids available in the EOTDA and elsewhere. The goal here is to demonstrate how weather decision aids can greatly enhance mission planning by exploiting both offensive and defensive weather sensitivities.

5. WIDA Model Validation

An integral part of the PL WIDA program is product validation. Two separate facilities are used to make comprehensive meteorological and sensor measurements. A fixed site at the Geophysics Directorate at Hanscom AFB, MA., (about 15 miles north of Boston) is used to collect all meteorological and EO data required by the ACT/EOS thermal models. Hiett (1995) provides a complete description of this facility. In addition to comprehensive meteorological and EO-related measurements, imagery is collected using a FLIR 2000 (8-12 pm), a FLIR PRISM (3-5 μm), and a TV camera (visible) observing two simple test targets. Currently, only the 8-12 μm data are being used for thermal-model validation and improvement.

A mobile platform has also been instrumented for ACT/EOS and NOWS validation measurements. Data collection using the mobile (trailer) facility will be primarily at the Camp Edwards range at Otis ANGB, Cape Cod, MA. For NOWS, the mobile facility includes measurements utilizing three laboratory-grade radiometers, NVGs, and tailored bar targets.

The fixed and mobile facilities are referred to as WIDA Lab, and data collected ensure that WIDA products will be thoroughly evaluated during their development.

6. Closing Remarks and Summary

The Department of Defense has spent considerable sums of money trying to engineer "all-weather" systems that are not impacted by the environment. A recent study by the GAO found that smart weapons were overrated. The study found that "all-weather" effectiveness was overstated by DoD, that precision guided munitions functioned effectively only in optimum conditions, and that IR, EO, and laser systems were seriously degraded by weather. Considerable improvement could be obtained by tailoring weapon choice, time of attack, and tactics to the weather. The use of validated environmental decision aids in mission execution and the automated mission planning process would bring current "smart systems" <u>closer</u> to the desired "all-weather" capability than trying to engineer-out the weather, and at a small fraction of the cost .

The WIDA program is developing products that translate conventional weather data into information that the warfighter needs to exploit the battlespace environment. This article presented an overview and progress report on projects that support air-to-ground IR targeting and operations using NVGS. Future efforts will incorporate weather sensitivities of other EO sensors into decision aids that will enhance all levels mission planning and execution.

Reference

1. Hiett, T. (1995) A User's Guide to the ACT/EOS Validation Experiment Level-2 Data Set, PL-TR-95-2136, Environmental Research Papers No. 1181, October 1995.

```
function [xO,dx,yO,dy,sr] = getfreq(s,par,receiv, range);
O/oGETFREQ get frequency response from OASP data
%                  First read it using READASCII
%
0/0         Syntax:
0/0
0/0         [x0,dx,sr]=getfreq(s, par,receiv,range,wavlt);
0/0
%
0/0         s,par    - input variable from READASCII
0/0         receiv  - vector with wanted receivers
0/0                      (scalar for only one)
0/0         range  - vector with wanted ranges
0/0                      (scalar for only one)



%----------------
nout     = par(l);
rd        = par(2);
rdlow  =  par(3);
ir         = par(4);
r0        = par(5);
rspace =  par(6);
nplots  =  par(7);
nx        = par(8);
lx         = par(9);
mx       = par(10);
dt         = par(1 1);
msuft  =  par(12);
o/o-.--------------

if (max(receiv)>ir)|(min(receiv)< 1 ),
         error('receivers out of range');
end;

if (max(range)>nplots)|(min(range)< 1 ),
         error('range out of range');
end;


dx        =  msuft*nplots*ir;
f          =  O:dx:(mx-lx)*dx;
dmsuft = nplots*ir;
dnplots          = ir;
```

```
range   =round(range);
receiv  =round(receiv);
sr      = [];

for x = (range-1 )*dnplots,
        for r=receiv,
                sr      = [sr s(f+x+(ir+l-r), l)];
        end;
end;

Xo      = r0 +rspace*(range( )-l);
dx      = rspace;

if (ir== 1 )
  dy=1;
else
  dy    = (rd-rdlow)/(ir-1);
end;
y0=rdlow+(receiv( l)- 1 )*dy;
```